Control Number: 52373

Item Number: 244

Public Utility Commission of Texas

Commissioner Memorandum

TO: Chairman Peter M. Lake
Commissioner Lori Cobos
Commissioner Jimmy Glotfelty

FROM: Commissioner Will McAdams

DATE: November 3, 2021

RE: Project No. 52373, Item No. 20 – *Review of Wholesale Electric Market Design*

As we have discussed reforms to the current market design, this Commission has heard from many stakeholders as they have presented a variety of issues that the ERCOT system may face in the coming years. These filings have presented such a broad spectrum of problems and solutions that I have found it difficult to see the forest for the trees in identifying those challenges that must be our first priority.

On October 25, 2021, ERCOT Staff published a report on the Impact of Growth in Wind and Solar on Net Load study and made it available to the public via their website. The document, attached to this memo, clearly articulates a realistic projection of solar deployment within the ERCOT system over the next two to three years and the resulting effect on the grid.

Pages 11 and 12 of the report demonstrate the effective magnitude of expected solar winter and spring ramp-downs over a two-hour period each evening. As we experienced during Winter Storm Uri, such a dramatic drop in available generation on the system, unless checked by rampable, dispatchable resources, can and will result in troubling frequency and inertial problems for the grid.

I file this memo with the accompanying report to provide the Commission and the public with a document that demonstrates the clearest example of a real-world challenge we must address through this proceeding. Fortunately, many of the tools we are developing now will directly help mitigate the risks to the system in coming years, but a sense of urgency is clearly needed.

I found that the report helped me find the forest despite the trees and has allowed me to prioritize the task before us. I look forward to discussing this memo and our other scheduled topics at our next work session.

Impact of Growth in Wind and Solar on Net Load

ERCOT Staff

October 25, 2021
WMWG

Things to be noted

- This study uses 2020 weather year and associated load, wind and solar profiles to build potential net load profiles with increased wind and solar penetration. Following are the assumptions used in this assessment that are worth noting,
  - Only net load up ramps have been analyzed.
  - No growth in demand/load.
  - Impact of year-to-year weather pattern changes not considered.
  - Impact of wind and solar curtailment due to transmission constraint is not considered.
  - Impact on system inertia due to decreases in net load and the impact of maintaining a minimum amount of reserves and critical inertia on net load is not considered.
  - Generation resource mix changes such as new resources other than wind as solar (such Energy Storage Resource, Combined Cycle Plants etc.) or retirement of thermal resource is not considered.

- Considering the notes above, the results presented in this slide deck should be viewed as indicative of operational trends but should not be considered a prediction of any specific future operating conditions.

Agenda

- Historical trends in net load
- Trends in net load as Wind and Solar capacities increase
- Grid and Market operations considerations

ercot

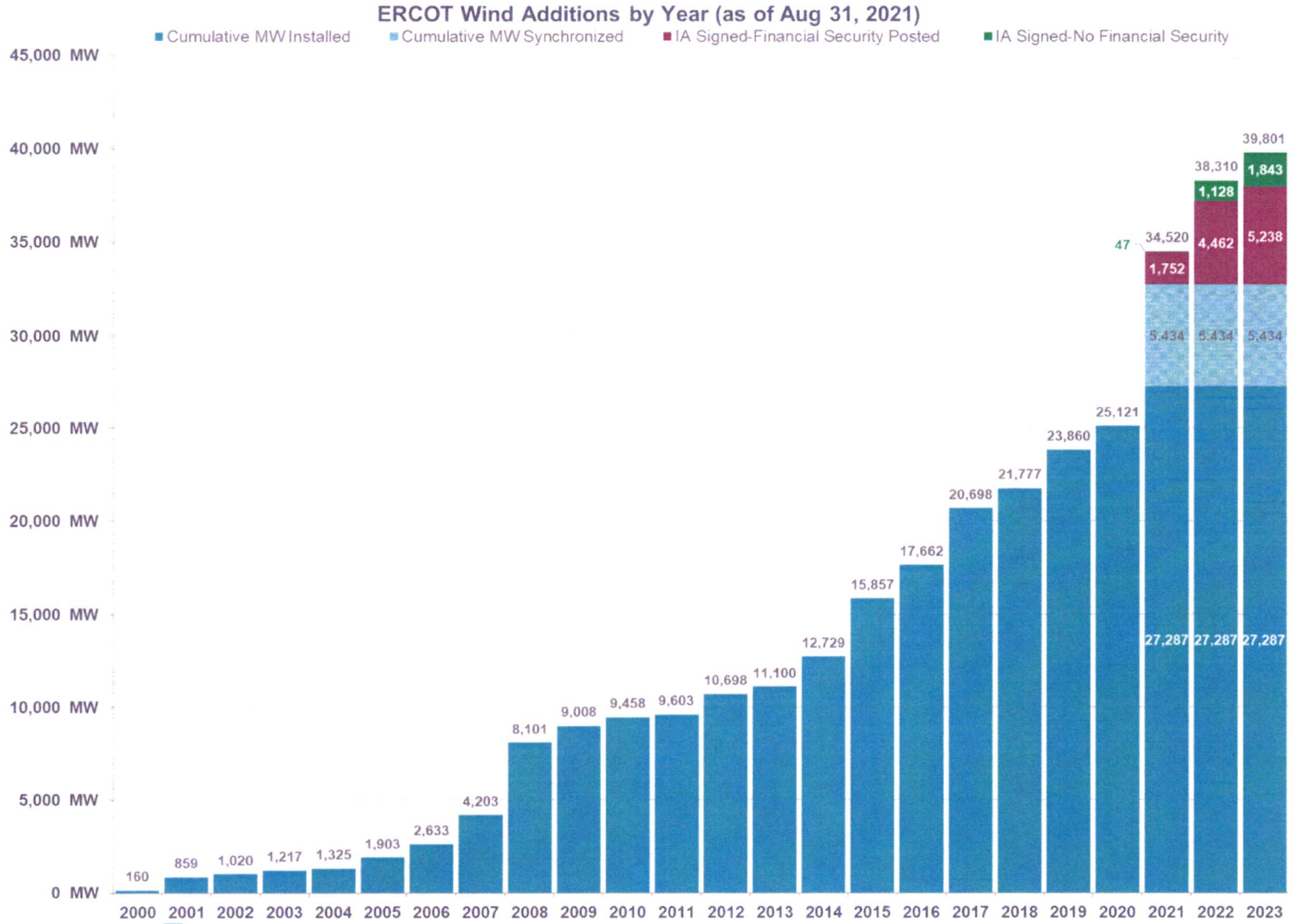
Introduction

- Solar installed capacity in ERCOT is expected to increase significantly over next 2-3 years. This growth in solar installed capacity may,
  - exaggerate the magnitude of the net load ramps that the grid may experience,
  - introduce more uncertainties in intra-hour and hourly net load forecasts, and
  - increase the potential for lower inertia during lighter load periods (typically in shoulder months).
- To assess the impact of growth in wind and solar on net load this study interpolated the 2020 wind and solar profiles to build expected net load profiles under the following 3 scenarios.
  - Upward net load changes in 5-min, 10-min, 30-min, 60-min and 180-min were analyzed.

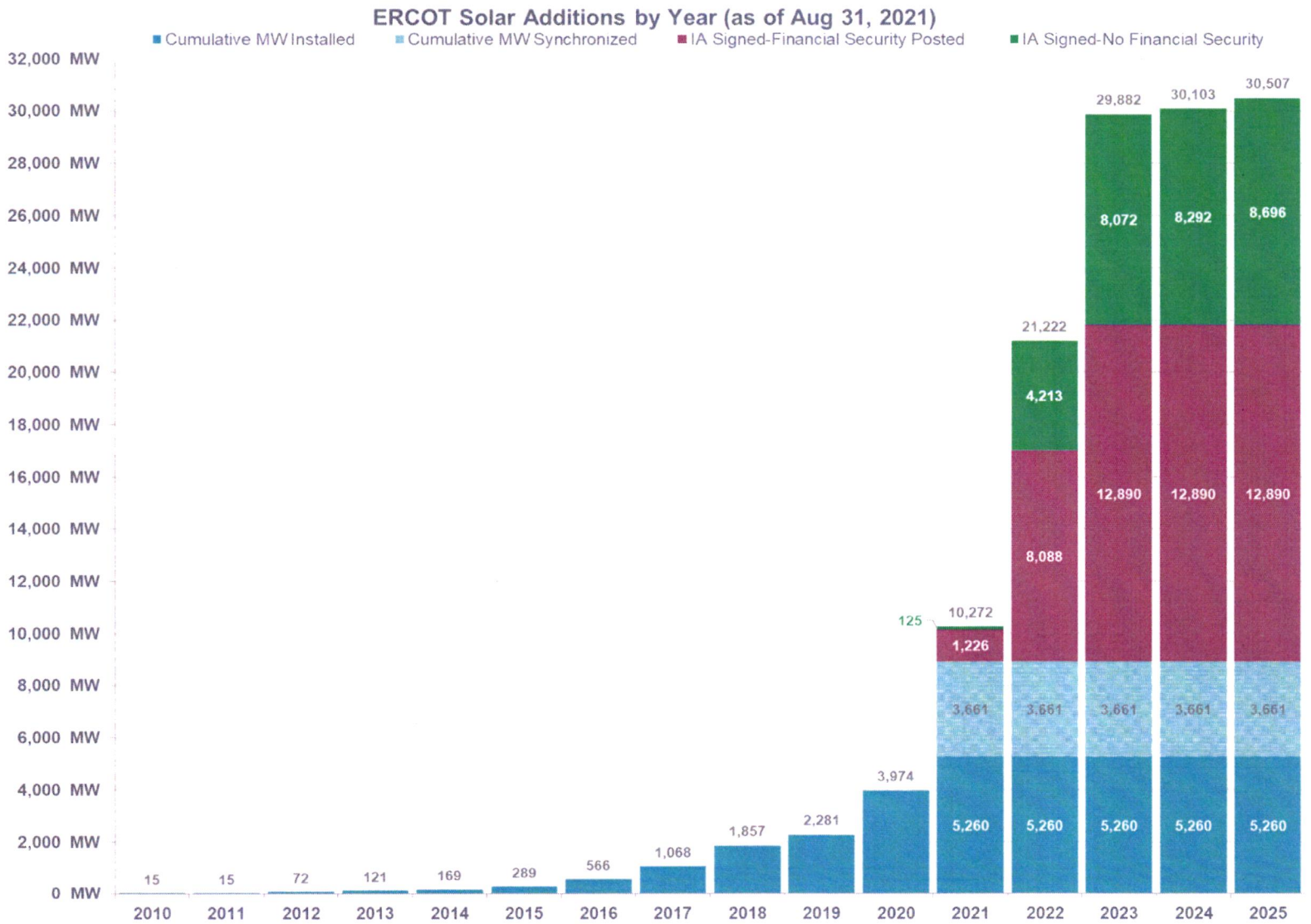
Scenario	Load	Wind Installed Capacity	Solar Installed Capacity
2020 (BASE)	2020 ERCOT Load	27 - 30 GW	2.5 - 5 GW
10 GW Solar	2020 ERCOT Load	35 GW	10 GW
20 GW Solar	2020 ERCOT Load	35 GW	20 GW
30 GW Solar	2020 ERCOT Load	35 GW	30 GW

- This slide deck will share observations and results from this assessment.

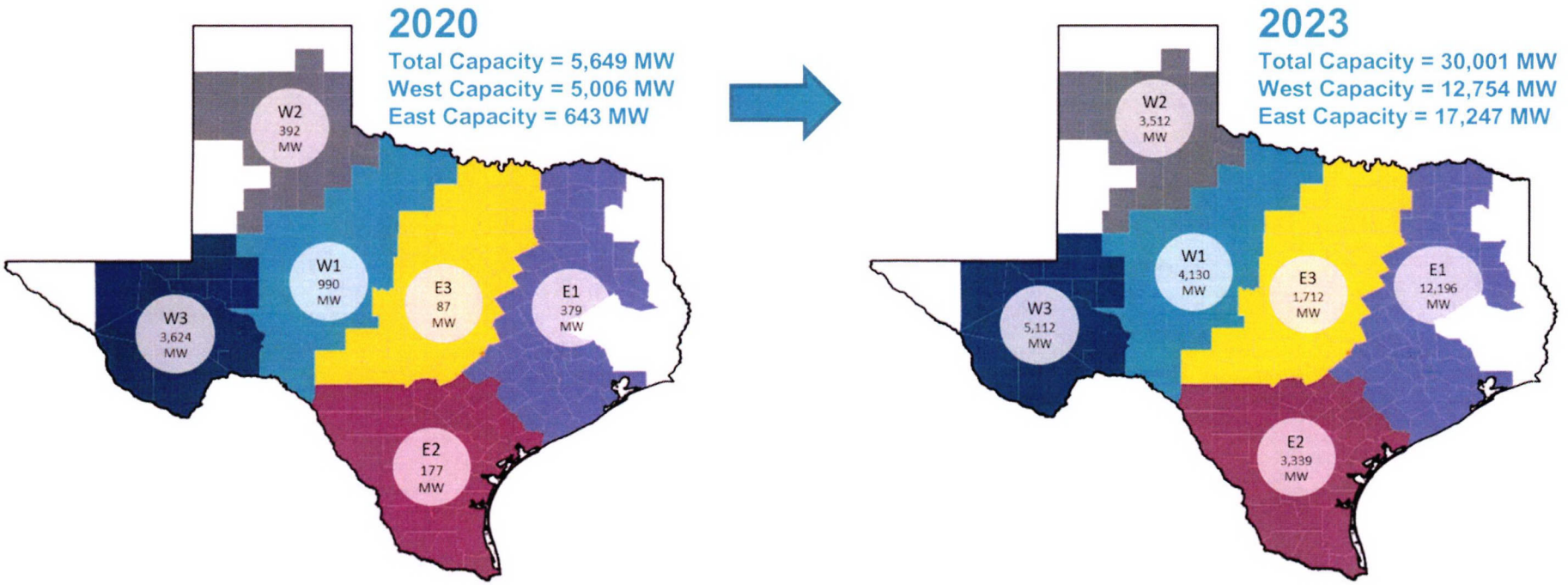
Growth in Wind Installed Capacity



Growth in Solar Installed Capacity



Solar Installed Capacity by Region

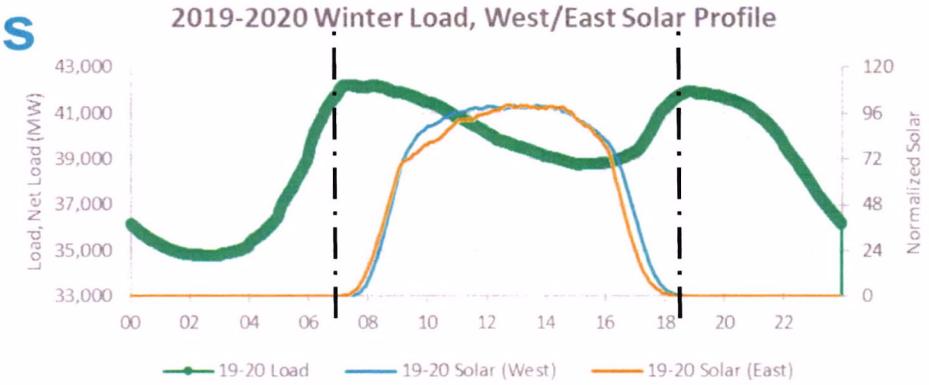


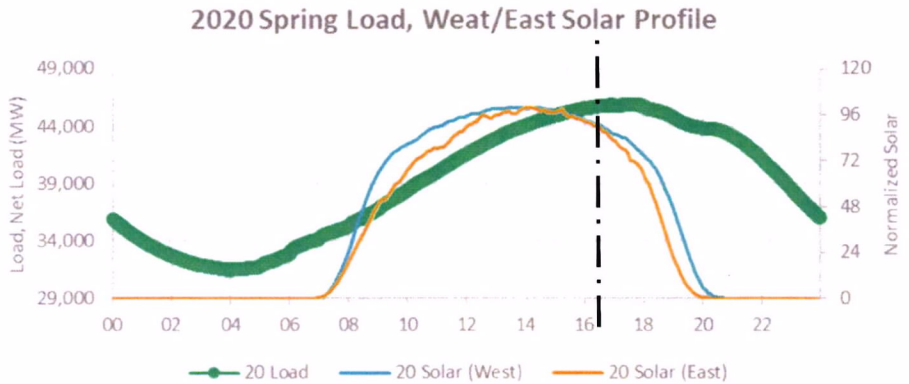
- A large concentration of exiting solar is in West Texas.
  - Installed capacity in the West regions is projected to triple by end of 2023.
- East regions have the greatest potential for solar growth.
  - Installed capacity in the East regions is projected to increase by ~15.9 GW by the end of 2023.
- Note that in 2020, the magnitude of solar resources in each of the 3 east solar regions wasn't sufficient to build representative solar generation profiles for every east solar region. Hence for the purposes of this analysis all three east regions were combined.

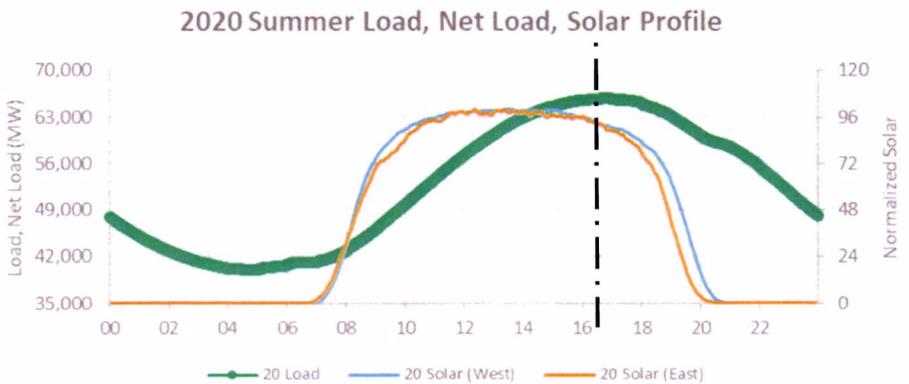
West and East Solar Profiles

- In Winter, solar generation in both regions ramps down to 0 MW before the evening load peak.

- In Spring and Summer, solar generation in both regions is better aligned with peak-load hours. Solar generation in West region ramps down later during sunset hours than in East region.

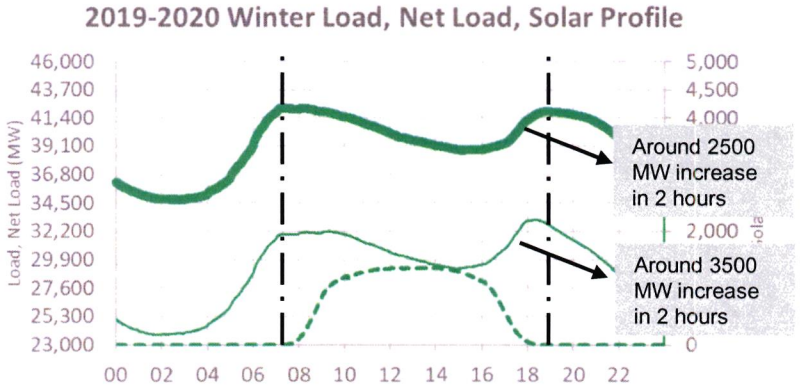


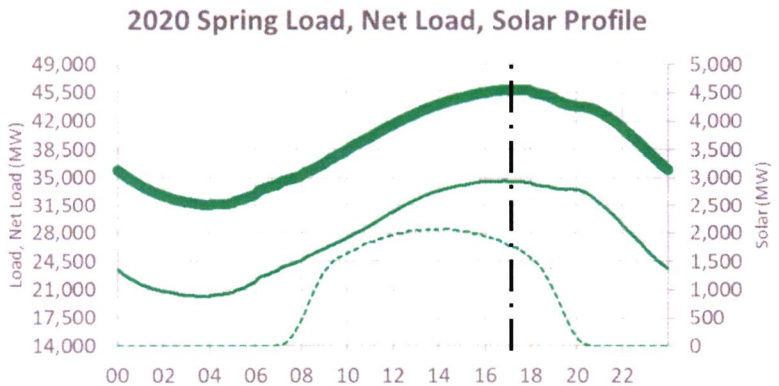


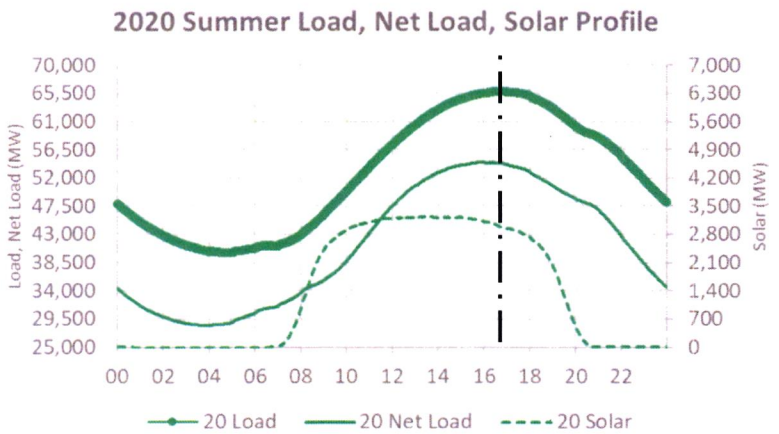


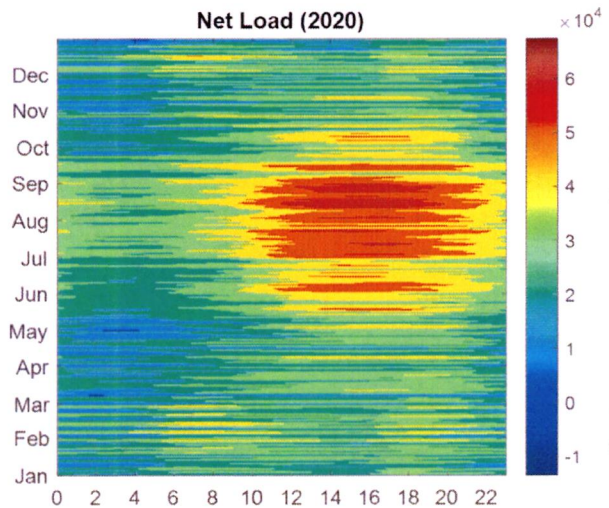
2020 Net Load Profile

- In 2020, that largest net load was primarily between HE12 and HE21 in the months of June through September.
- Peak net load hour was generally corelated with the peak load hour.
- During winters, typically the evening load peaks around HE19/20. Sunset starts reducing solar output between HE15 and HE19. Reduction in solar output exacerbated/magnified the net load up ramp during these hours.



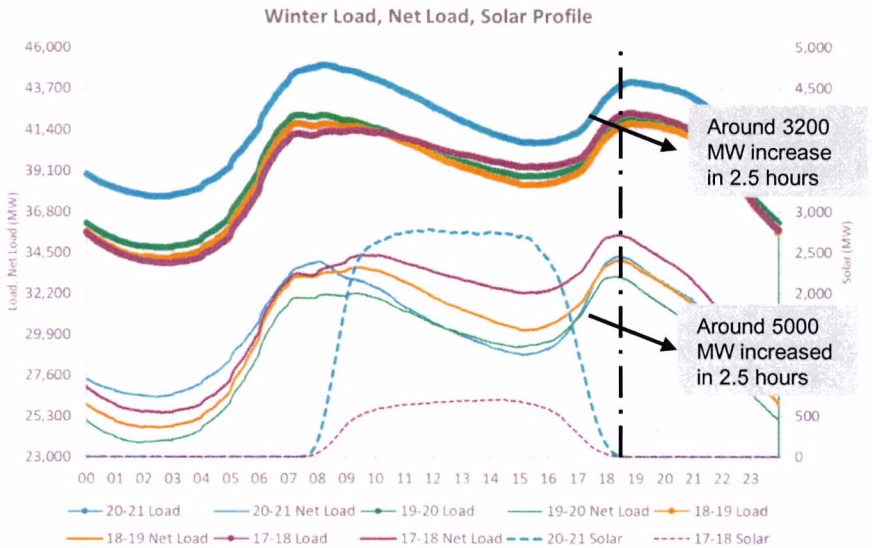


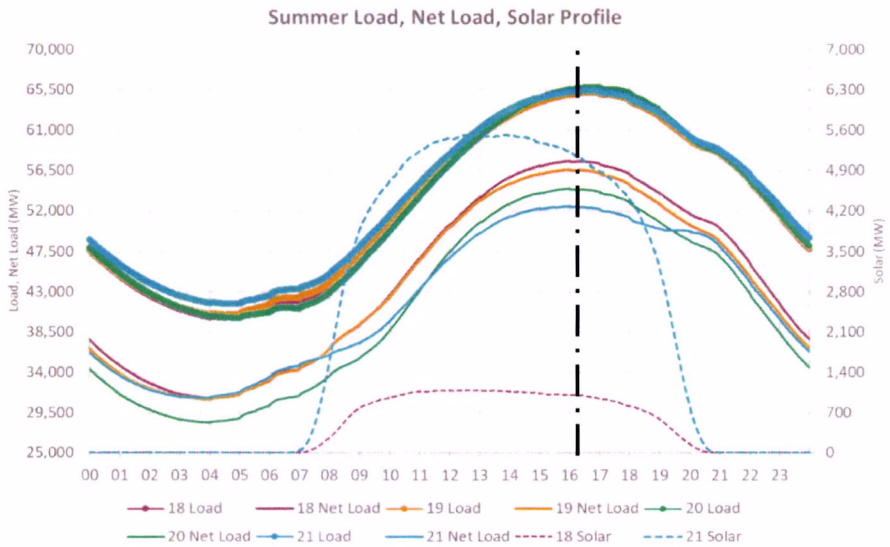


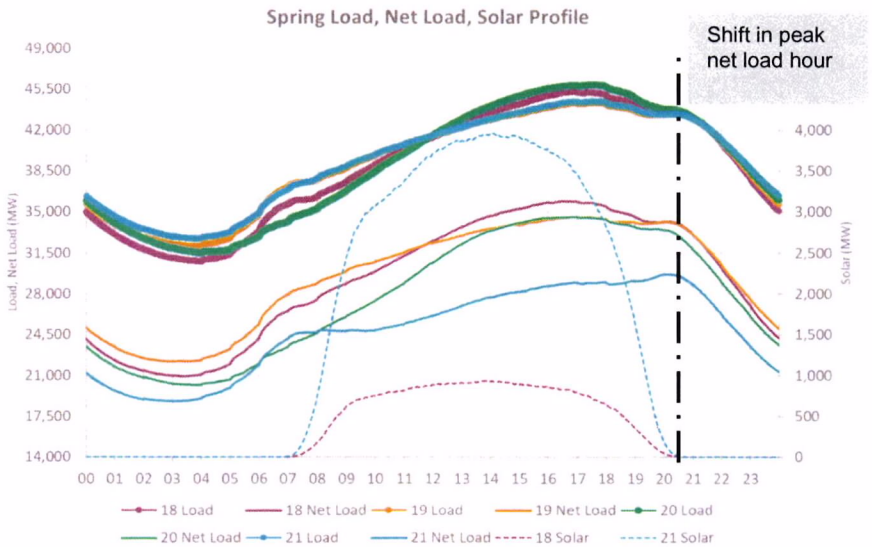


2018 - 2021 Seasonal Net Load Profile Comparison

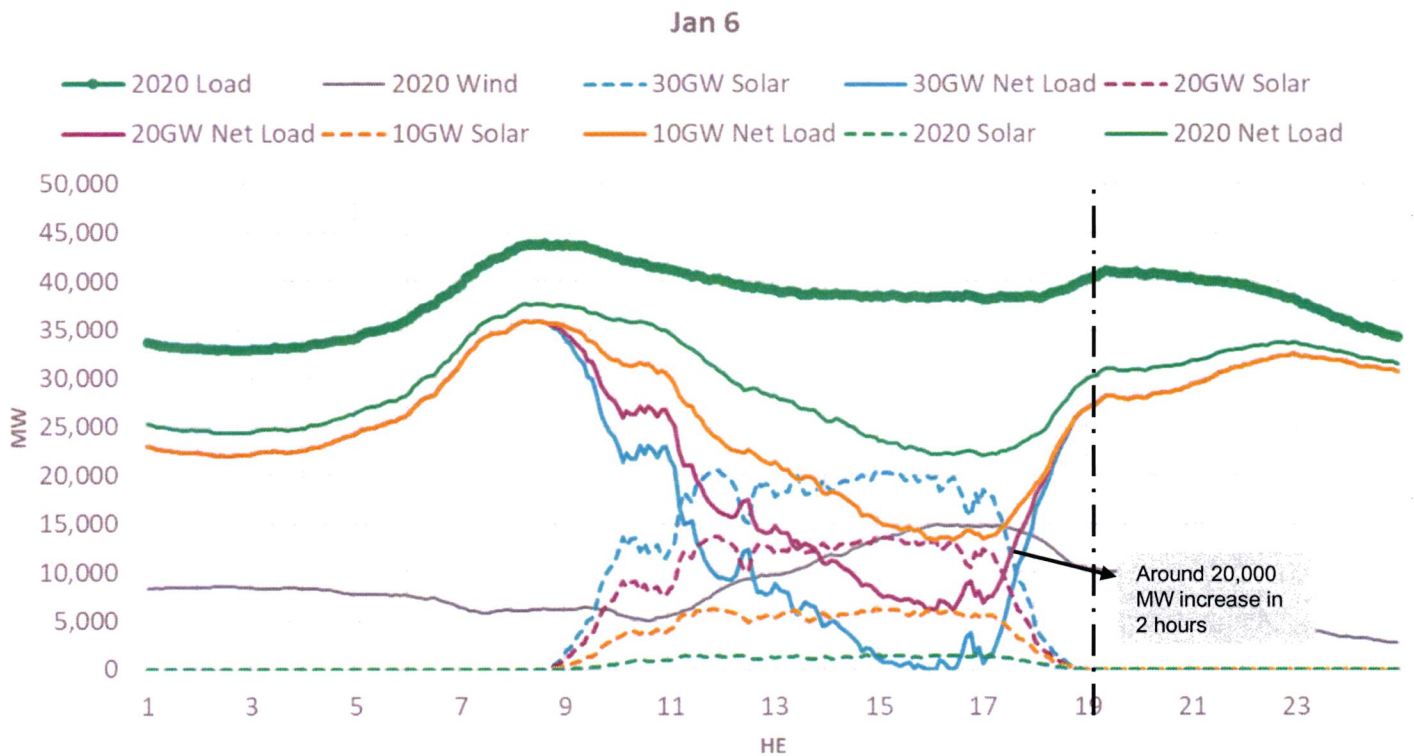
- During the evening hours in 2020-2021 winter season, on average the net load ramped up at a much faster rate than the load ramp.
- Peak net load hour in spring has a visible shift to be in HE21.





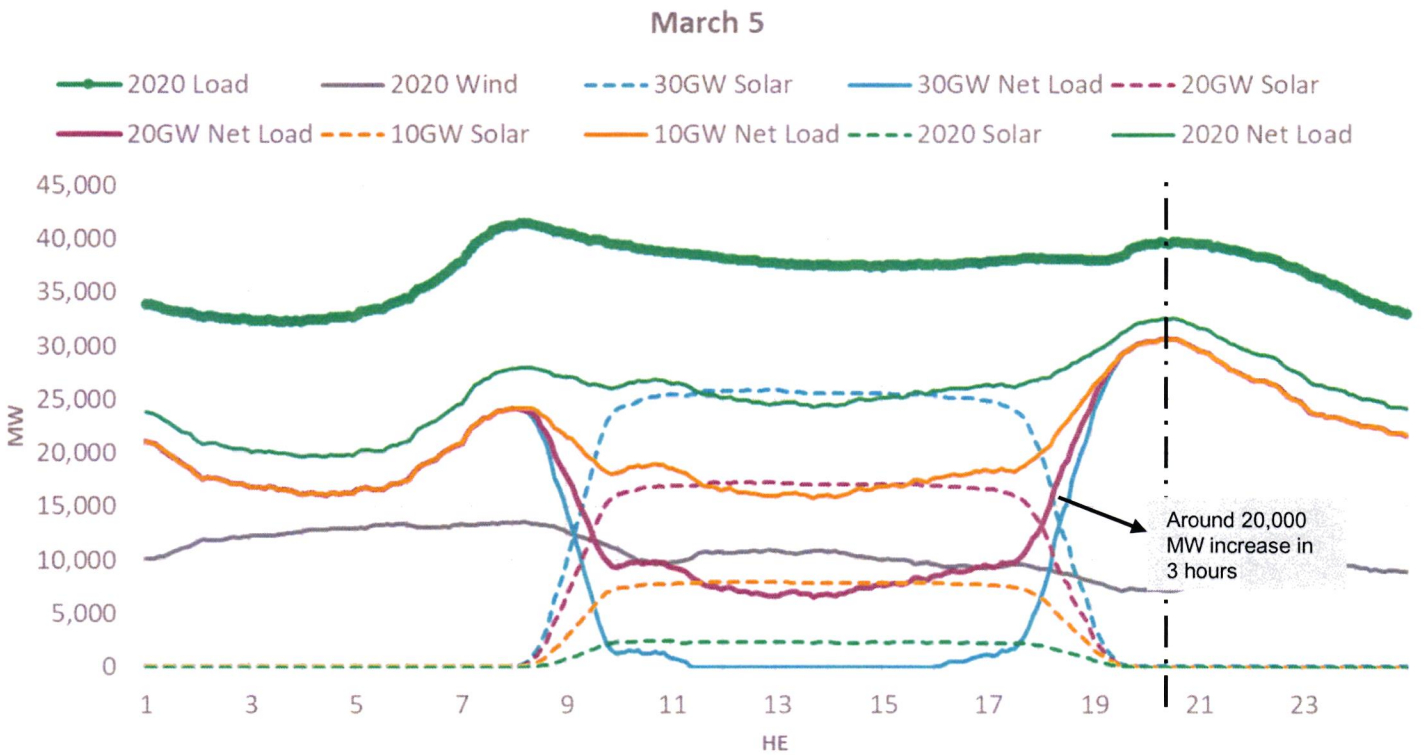


A Mockup of Net Load Profile with only growth in Wind & Solar – January 6*



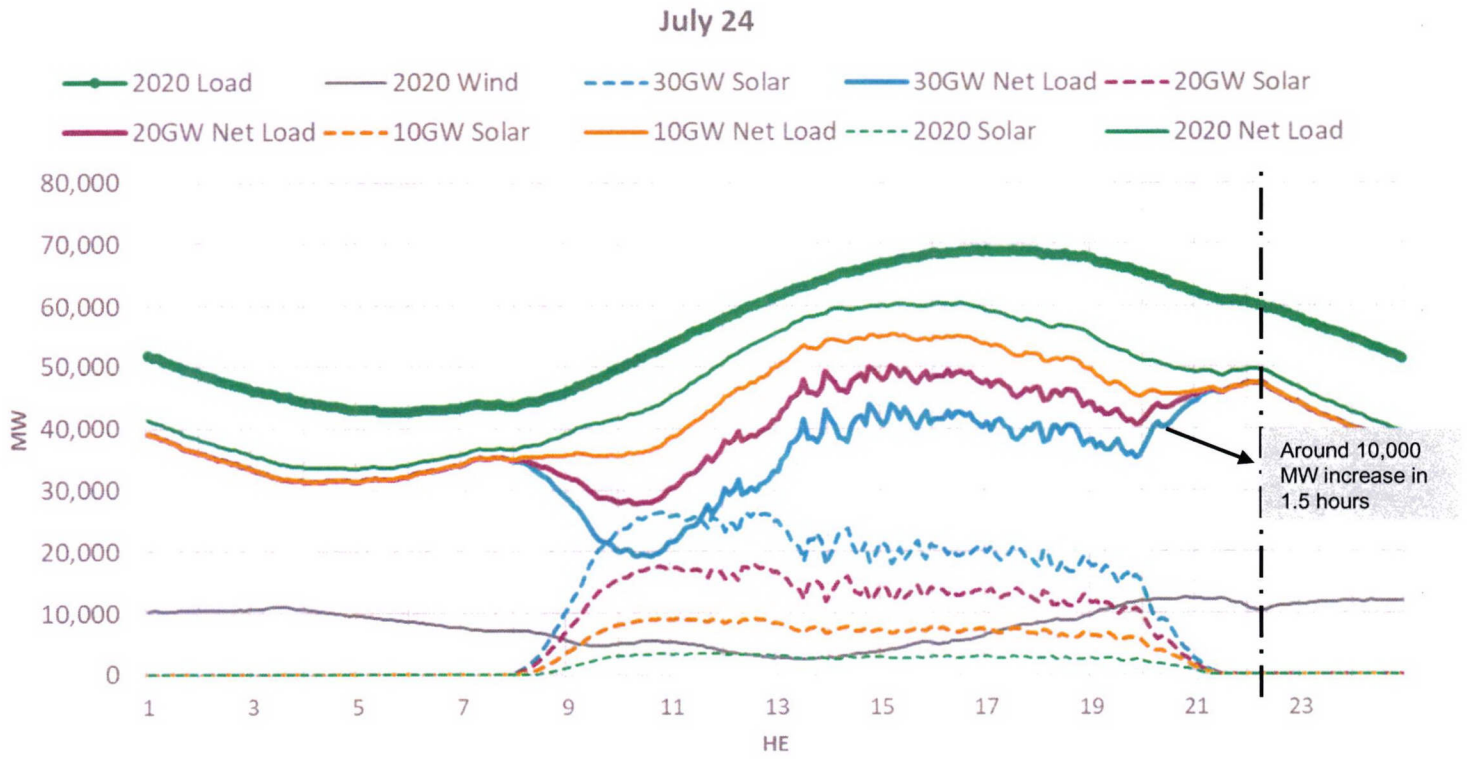
*Note: Slide 2 outlines the assumptions that were used in this assessment. This analysis is based on extrapolating the wind and solar generation profiles from 2020. The locations of future solar farms (geographic effect), wind/solar curtailment and dispatch of other resources will change the actual net load ramps the grid experiences.

A Mockup of Net Load Profile with only growth in Wind & Solar – March 5*



*Note: Slide 2 outlines the assumptions that were used in this assessment. This analysis is based on extrapolating the wind and solar generation profiles from 2020. The locations of future solar farms (geographic effect), wind/solar curtailment and dispatch of other resources will change the actual net load ramps the grid experiences.

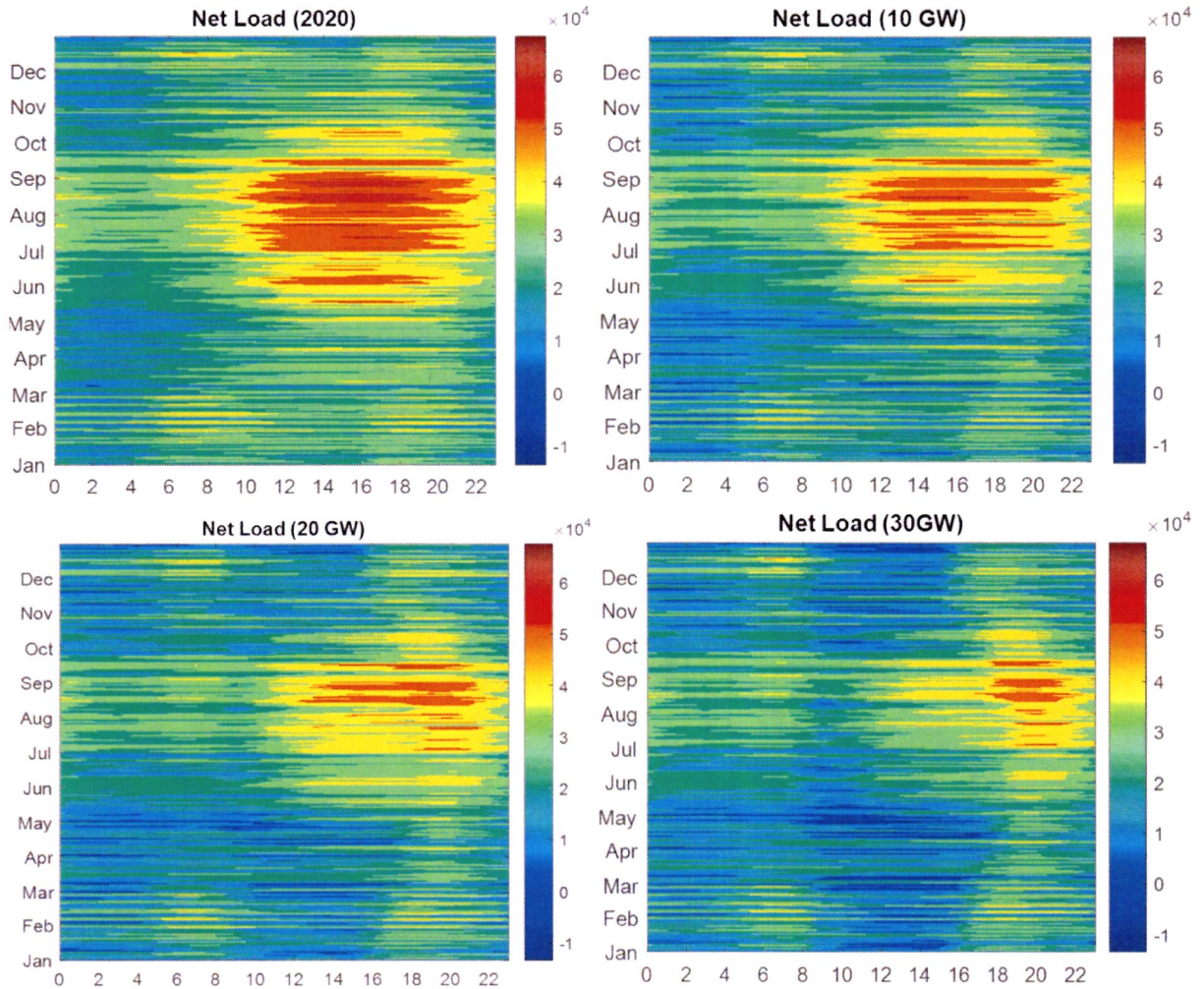
A Mockup of Net Load Profile with only growth in Wind & Solar – July 24*



*Note: Slide 2 outlines the assumptions that were used in this assessment. This analysis is based on extrapolating the wind and solar generation profiles from 2020. The locations of future solar farms (geographic effect), wind/solar curtailment and dispatch of other resources will change the actual net load ramps the grid experiences.

Net Load with growth in Wind and Solar*

- As the amount of solar installed capacity increases
  - The magnitude of peak net load will reduce (visible reduction in red shades in the heat maps).
  - The hour at which peak net load occurs shifts to being more correlated with the sunset hours.
  - Periods with lower net load specifically during the shoulder months will increase (visible increase in blue shades in the heat maps).

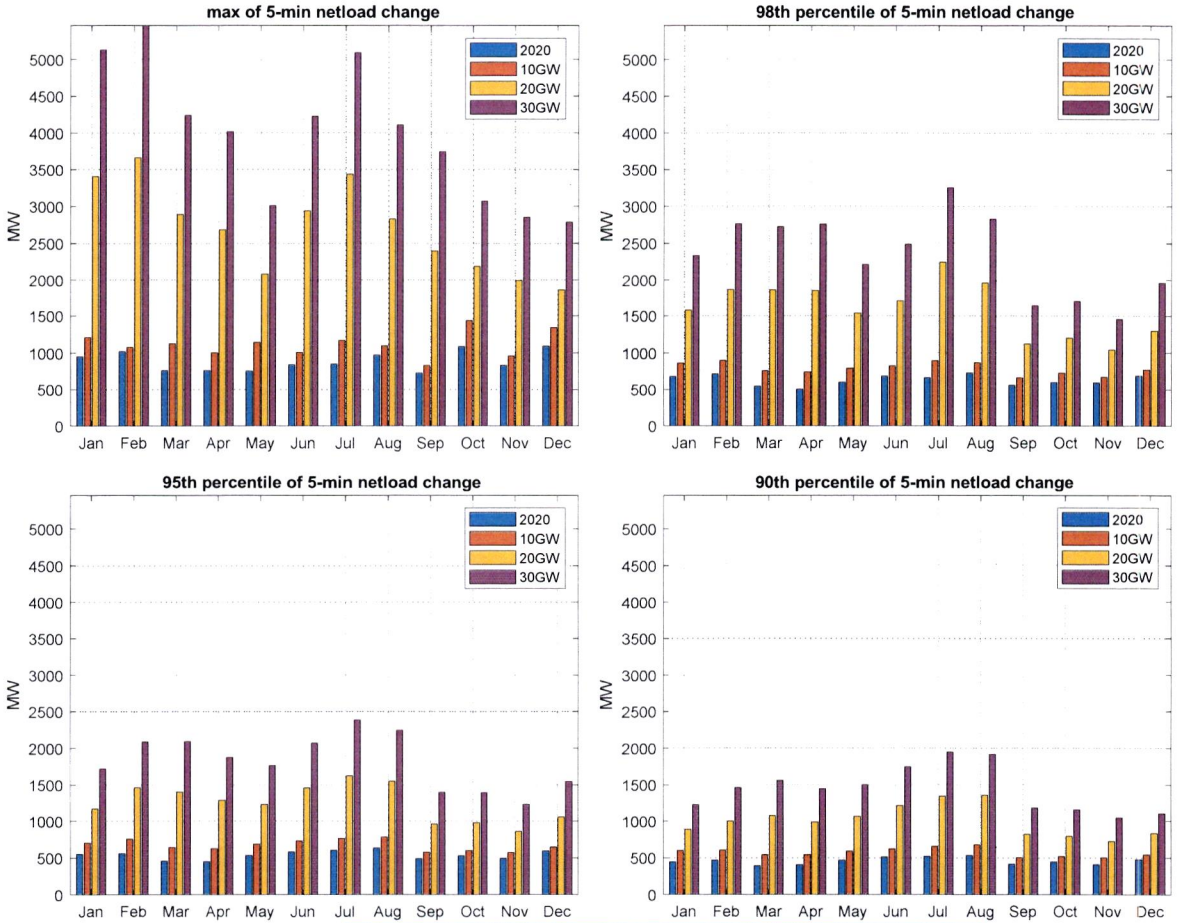


*Note: Slide 2 outlines the assumptions that were used in this assessment. This analysis is based on extrapolating the wind and solar generation profiles from 2020. The locations of future solar farms (geographic effect), wind/solar curtailment and dispatch of other resources will change the actual net load ramps the grid experiences.

5-min Net Load Change

- In comparison to 2020, on an average
  - there is a marginal increase in the 5-min net load ramps in the 10 GW scenario.
  - the 5-min net load ramps increase by ~150% in the 20 GW scenario.
  - the 5-min net load ramps increase by ~300% in the 30 GW scenario
  - Winter, Spring and Summer months have the most prominent changes in extreme 5-min net load ramp magnitudes.

- There is a vast difference between the maximum value and the 98th percentile. This signifies that the most extreme 5-min net load ramps occur very few times.



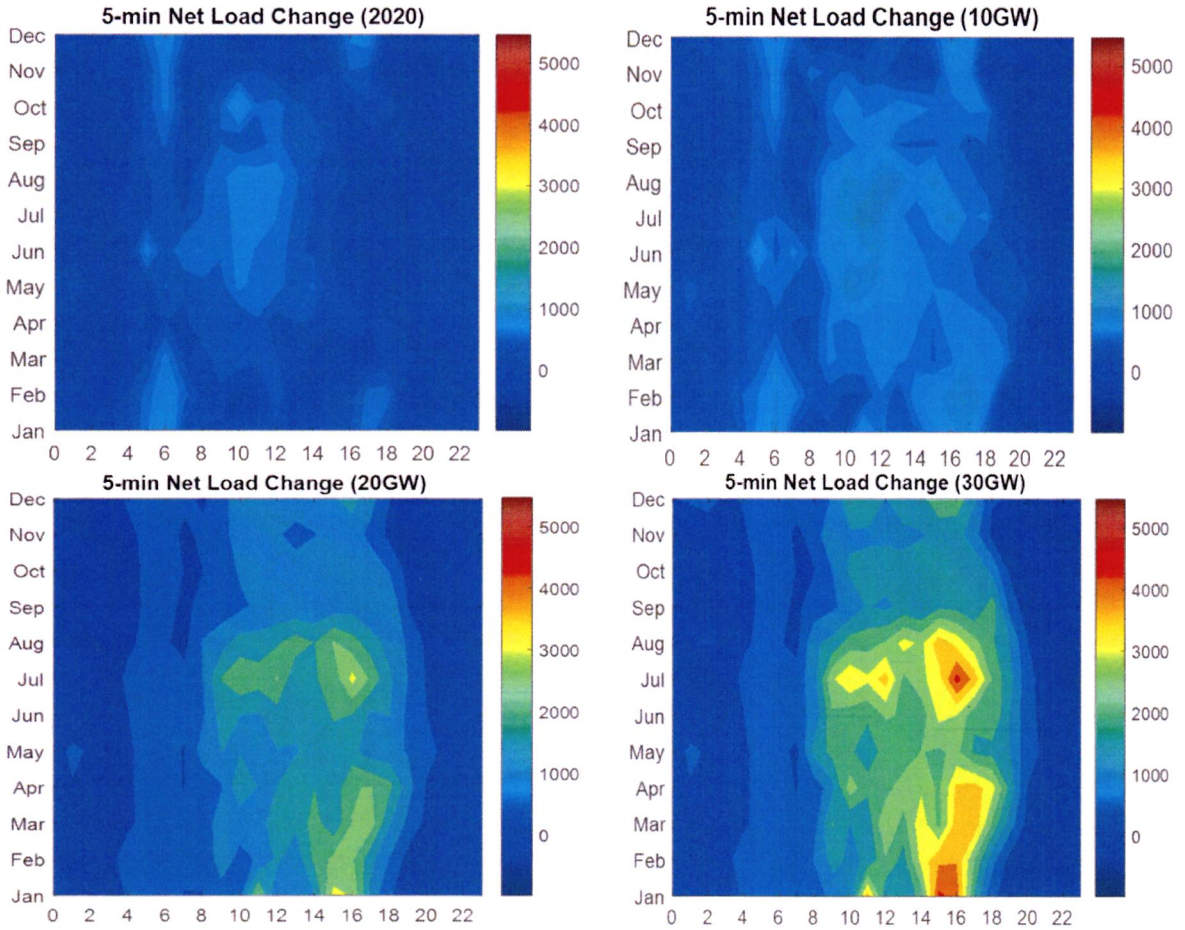
	5-min Net Load Up Change			
Scenario	Max	98th	95th	90th
2020	1,094	729	634	533
10 GW	1,436	899	783	678
20 GW	3,664	2,245	1,627	1,359
30 GW	5,466	3,254	2,386	1,946

5-min Net Load Change - 95th percentile

From previous slide….

- In comparison to 2020, on an average
  - there is a marginal increase in the 5-min net load ramps in the 10 GW scenario.
  - the 5-min net load ramps increase by ~150% in the 20 GW scenario.
  - the 5-min net load ramps increase by ~300% in the 30 GW scenario
  - Winter, Spring and Summer months have the most prominent changes in extreme 5-min net load ramp magnitudes.

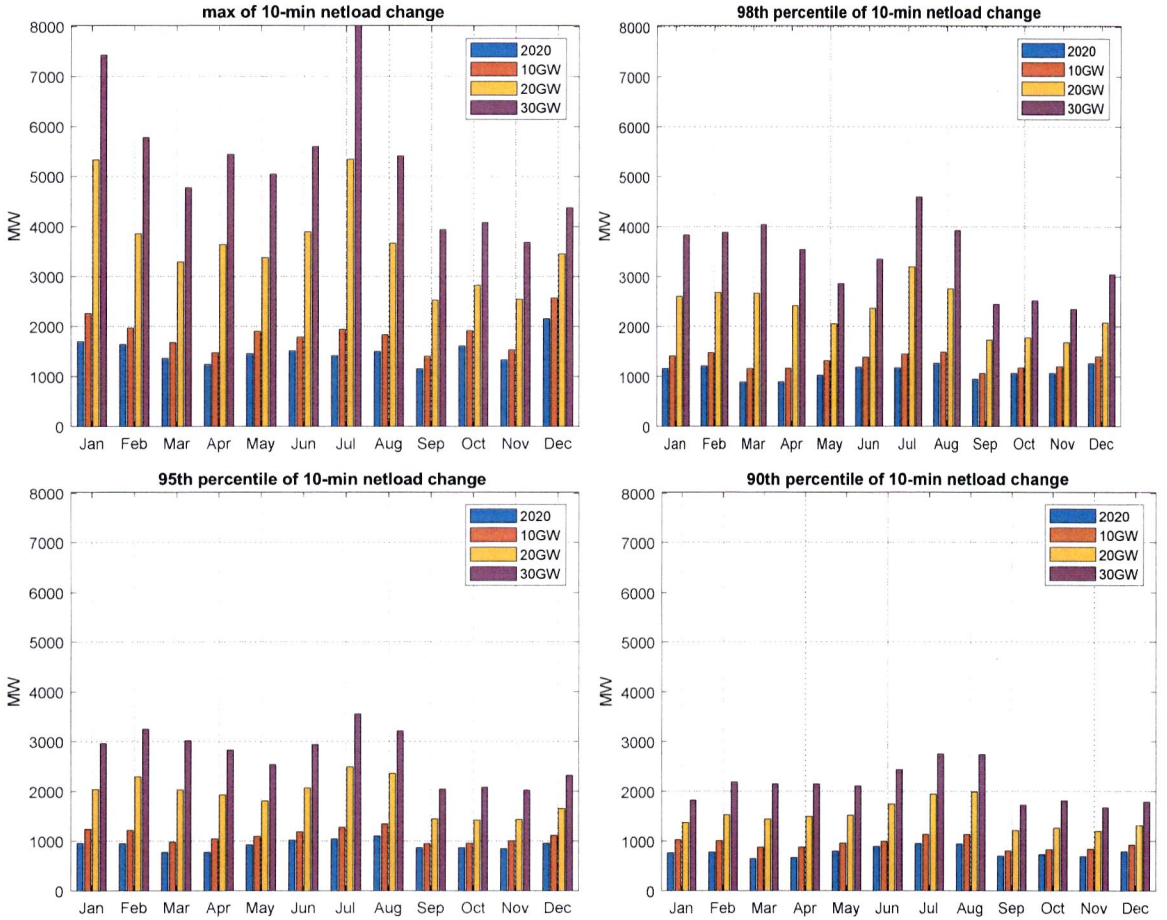
  - In Winter and Spring the extreme 5-min net load ramps are correlated with sunset hours.



10-min Net Load Change

- In comparison to 2020, on an average
  - there is a marginal increase in the 10-min net load ramps in the 10 GW scenario.
  - the 10-min net load ramps increase by ~150% in the 20 GW scenario.
  - the 10-min net load ramps increase by ~250% in the 30 GW scenario
  - Winter, Spring and Summer months have the most prominent changes in extreme 10-min net load ramp magnitudes.

- There is a vast difference between the maximum value and the 98th percentile. This signifies that the most extreme 10-min net load ramps occur very few times.

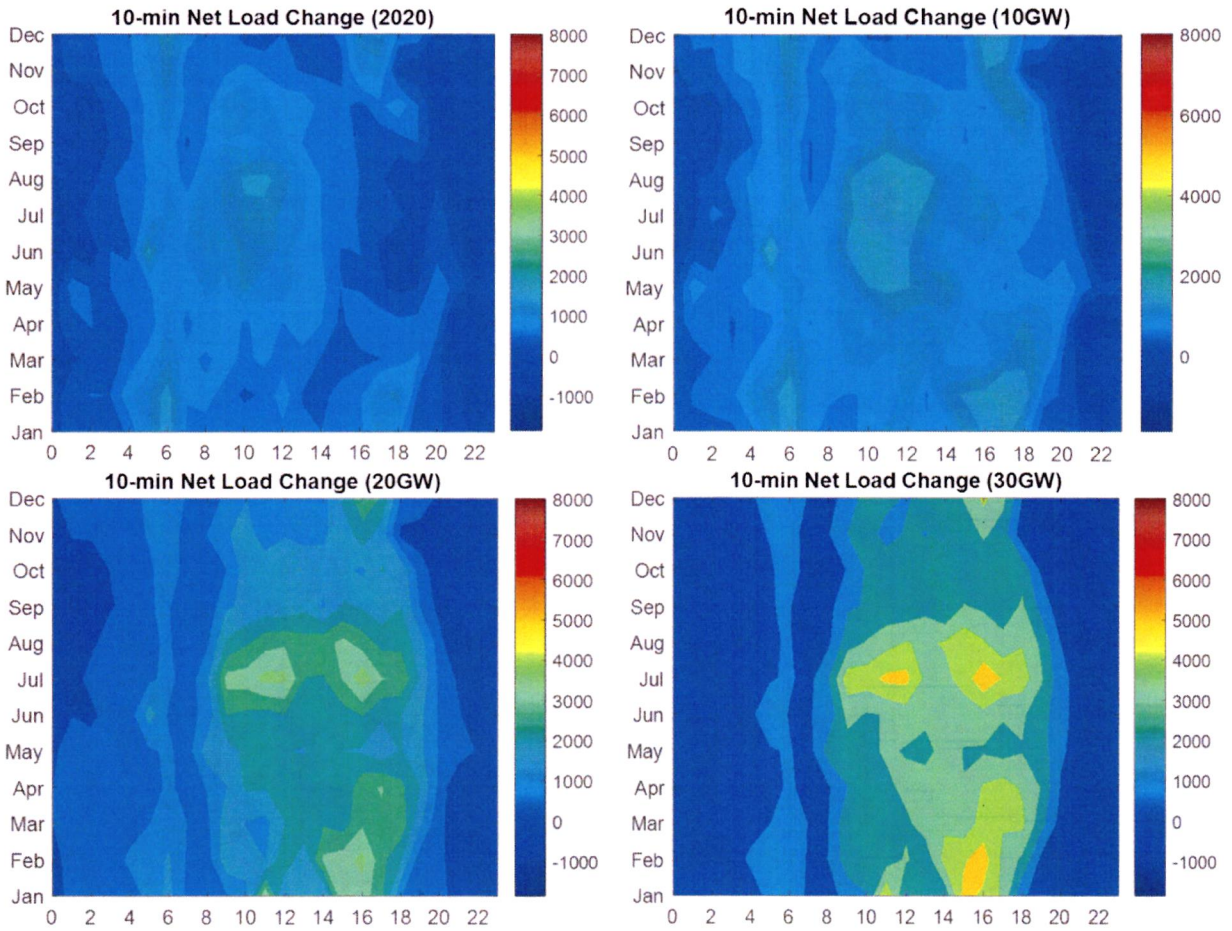


Scenario	10-min Net Load Up Change (MW)			
	Max	98th	95th	90th
2020	2,154	1,265	1,107	949
10 GW	2,571	1,489	1,347	1,139
20 GW	5,343	3,197	2,497	1,987
30 GW	8,022	4,595	3,560	2,753

10-min Net Load Change - 95th percentile

From previous slide….

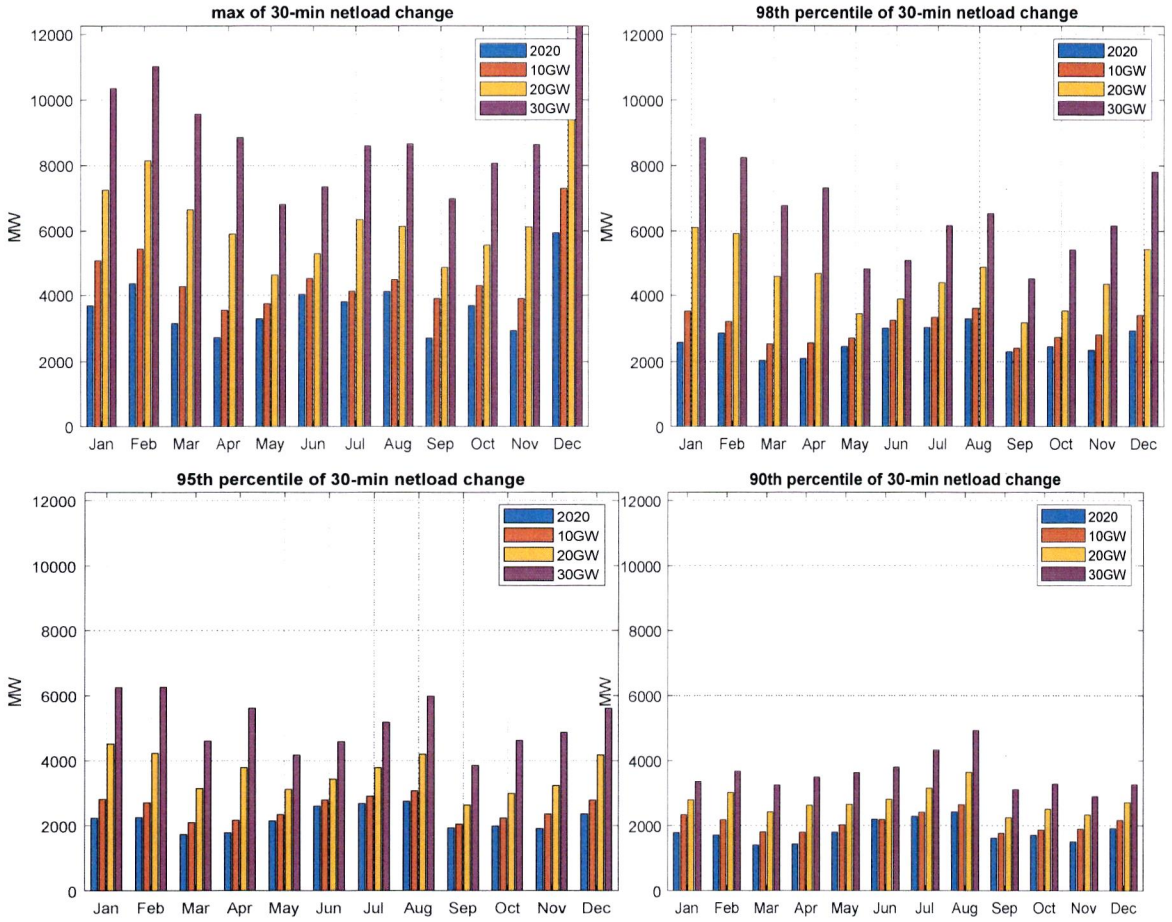
- In comparison to 2020, on an average
  - there is a marginal increase in the 10-min net load ramps in the 10 GW scenario.
  - the 10-min net load ramps increase by ~150% in the 20 GW scenario.
  - the 10-min net load ramps increase by ~250% in the 30 GW scenario
  - Winter, Spring and Summer months have the most prominent changes in extreme 10-min net load ramp magnitudes.
  - In Winter and Spring the extreme 10-min net load ramps are correlated with sunset hours.



30-min Net Load Change

- In comparison to 2020, on an average
  - there is a marginal increase in the 30-min net load ramps in the 10 GW scenario.
  - the 30-min net load ramps increase by ~75% in the 20 GW scenario.
  - the 30-min net load ramps increase by ~150% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 30-min net load ramp magnitudes.

- There is a vast difference between the maximum value and the 98th percentile. This signifies that the most extreme 30-min net load ramps occur very few times.



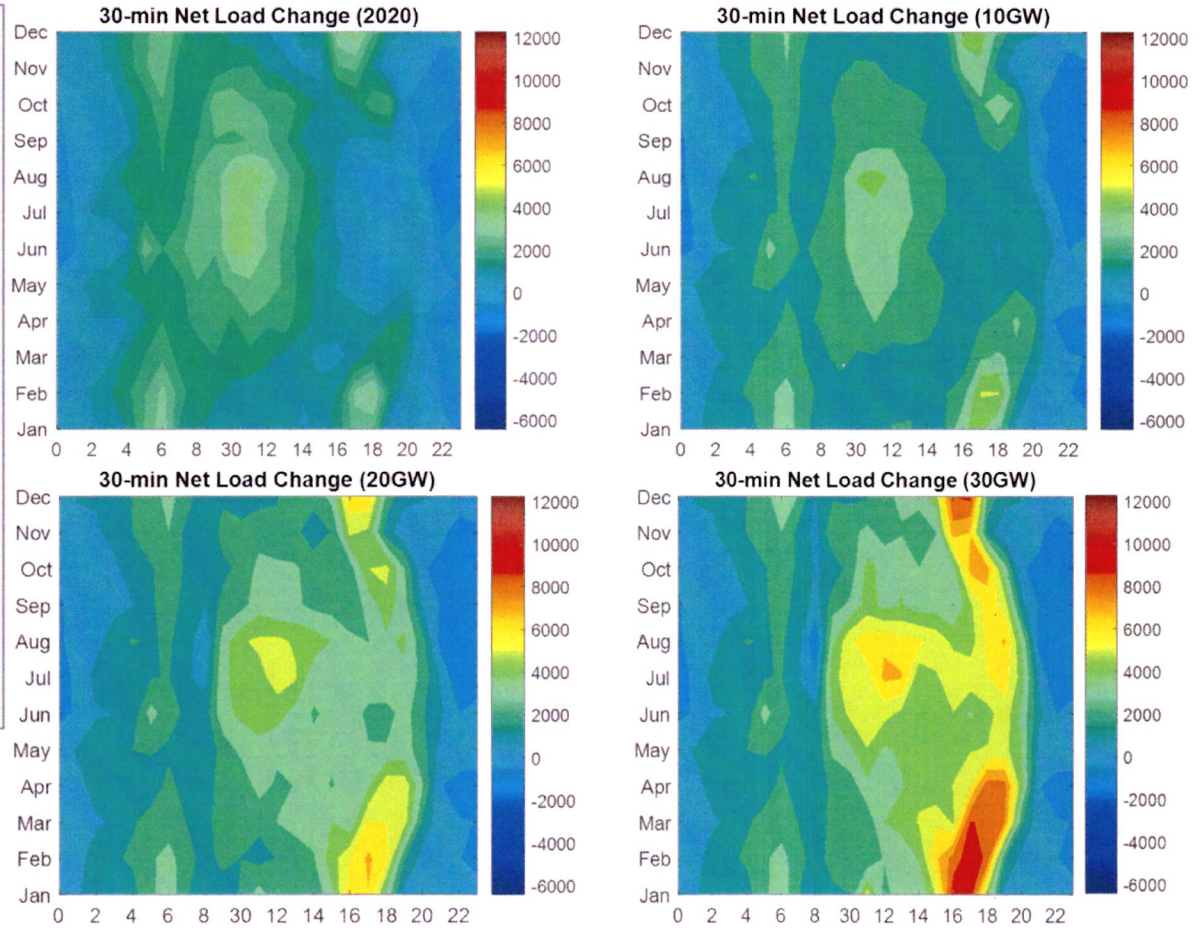
	30-min Net Load Up Change (MW)			
Scenario	Max	98th	95th	90th
2020	5,944	3,290	2,743	2,419
10 GW	7,302	3,604	3,069	2,651
20 GW	9,672	6,106	4,507	3,645
30 GW	12,259	8,846	6,256	4,931

30-min Net Load Change - 95th percentile

From previous slide….

- In comparison to 2020, on an average
  - there is a marginal increase in the 30-min net load ramps in the 10 GW scenario.
  - the 30-min net load ramps increase by ~75% in the 20 GW scenario.
  - the 30-min net load ramps increase by ~150% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 30-min net load ramp magnitudes.

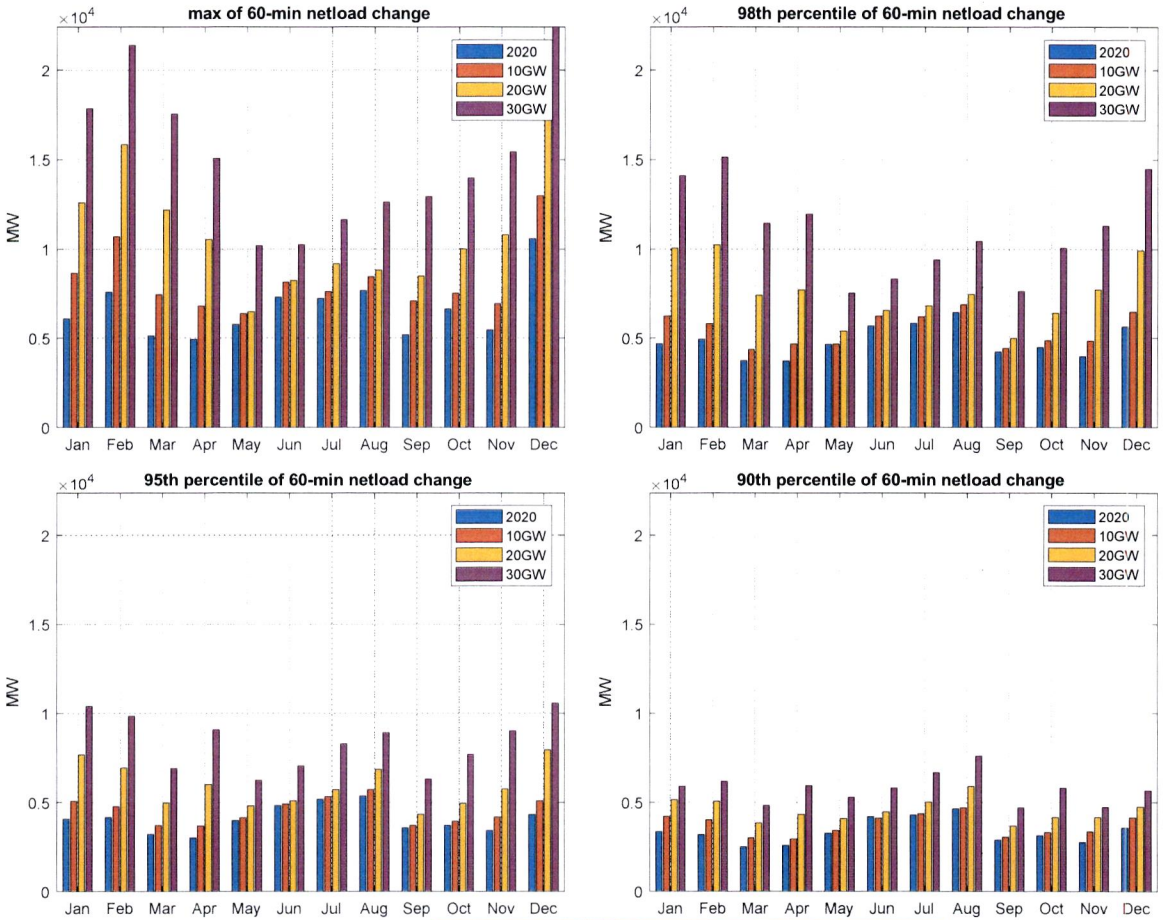
  - In Winter, Spring and late Summer the extreme 30-min net load ramps are correlated with sunset hours.



60-min Net Load Change

- In comparison to 2020, on an average
  - there is a marginal increase in the 60-min net load ramps in the 10 GW scenario.
  - the 60-min net load ramps increase by ~65% in the 20 GW scenario.
  - the 60-min net load ramps increase by ~125% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 60-min net load ramp magnitudes.

- There is a vast difference between the maximum value and the 98th percentile. This signifies that the most extreme 60-min net load ramps occur very few times.



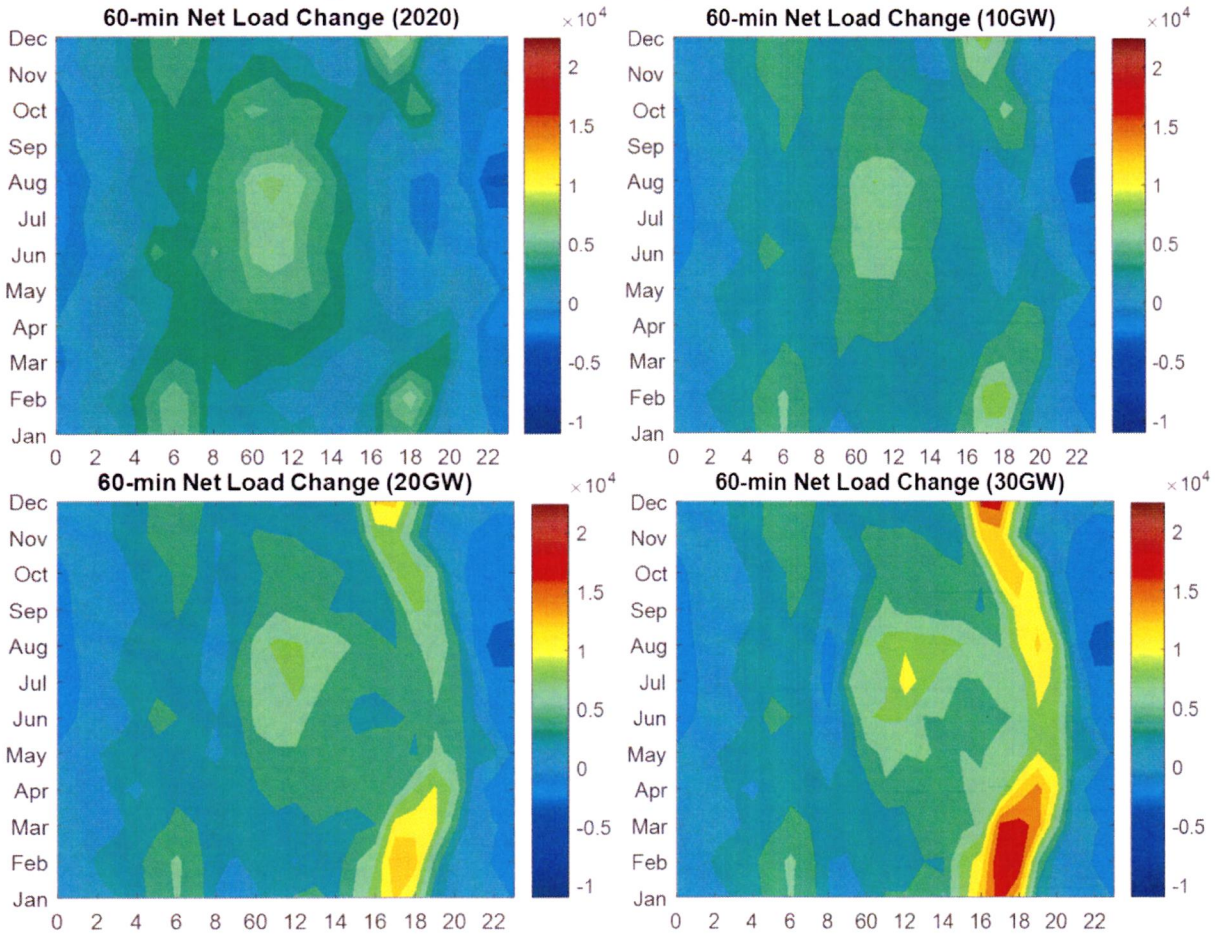
	60-min Net Load Up Change (MW)			
Scenario	Max	98th	95th	90th
2020	10,595	6,442	5,354	4,640
10 GW	12,981	6,884	5,717	4,704
20 GW	17,601	10,233	7,931	5,904
30 GW	22,417	15,141	10,574	7,597

60-min Net Load Change - 95th percentile

From previous slide….

- In comparison to 2020, on an average
  - there is a marginal increase in the 60-min net load ramps in the 10 GW scenario.
  - the 60-min net load ramps increase by ~65% in the 20 GW scenario.
  - the 60-min net load ramps increase by ~125% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 60-min net load ramp magnitudes.

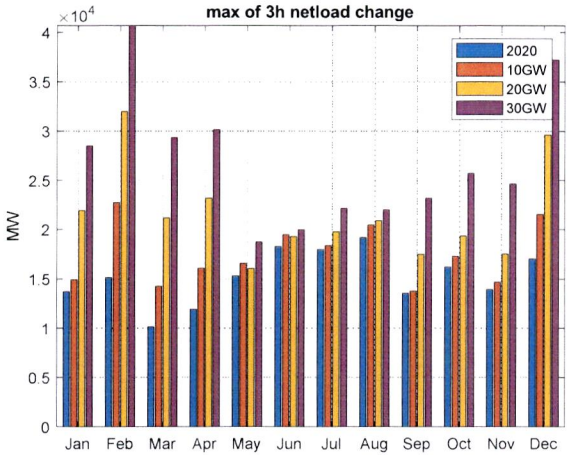
  - In Winter, Spring and late Summer the extreme 60-min net load ramps are correlated with sunset hours.

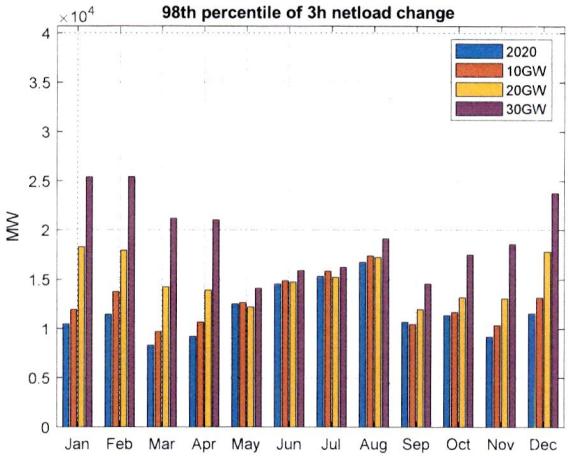


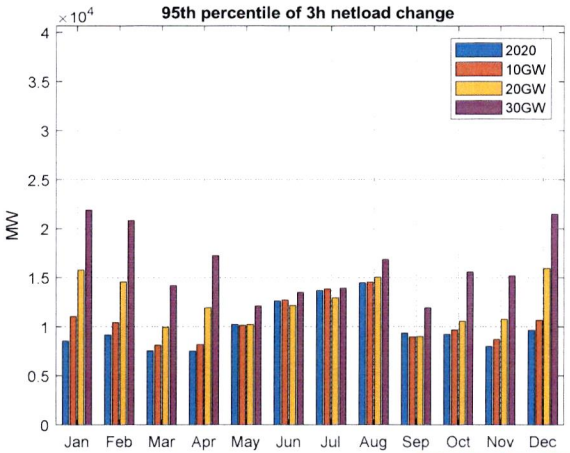
180-min Net Load Change

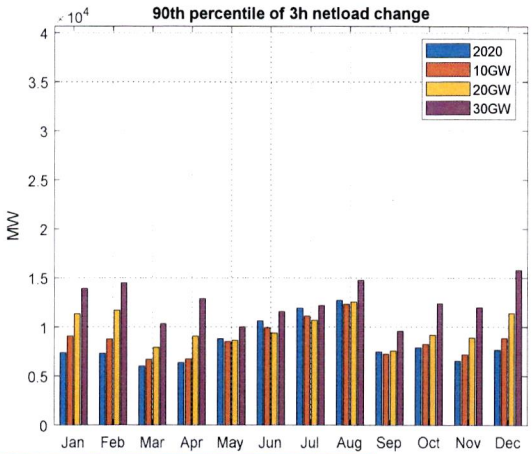
- In comparison to 2020, on an average
  - there is a marginal increase in the 180-min net load ramps in the 10 GW scenario.
  - the 180-min net load ramps increase by ~50% in the 20 GW scenario.
  - the 180-min net load ramps increase by ~85% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 180-min net load ramp magnitudes.

- There is a vast difference between the maximum value and the 98th percentile. This signifies that the most extreme 180-min net load ramps occur very few times.







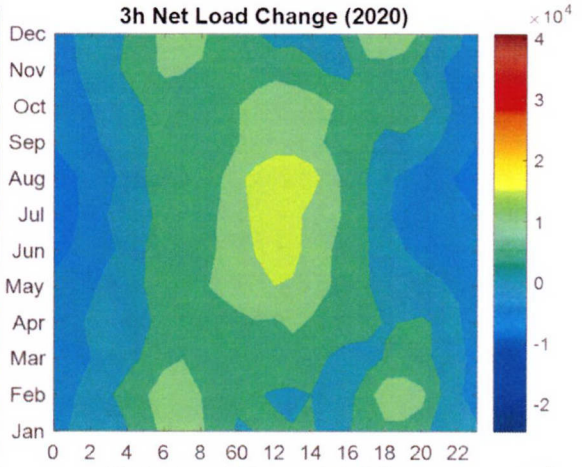


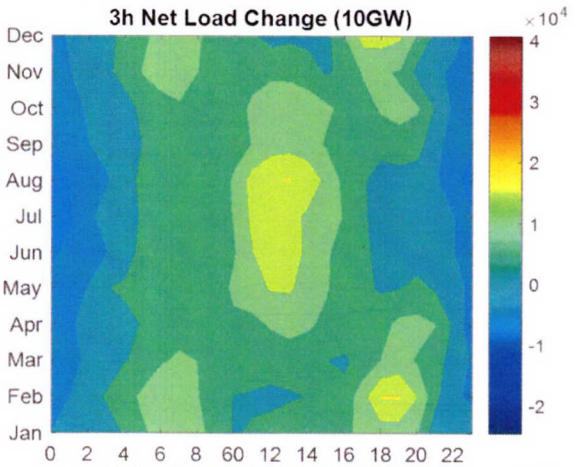
	180-min Net Load Up Change (MW)			
Scenario	Max	98th	95th	90th
2020	19,191	16,763	14,457	12,728
10 GW	22,722	17,381	14,533	12,340
20 GW	31,998	18,285	15,765	12,549
30 GW	40,684	25,424	21,909	14,754

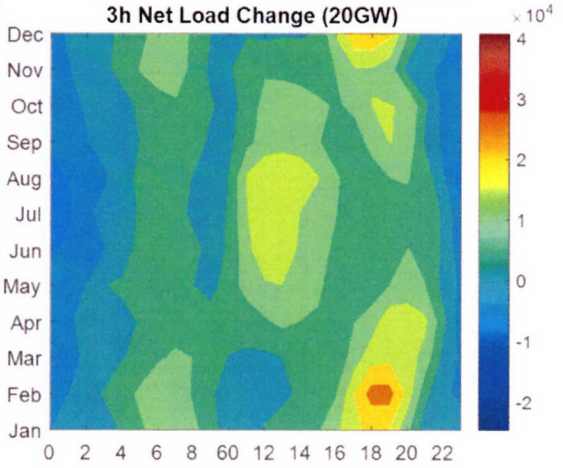
180-min Net Load Change - 95th percentile

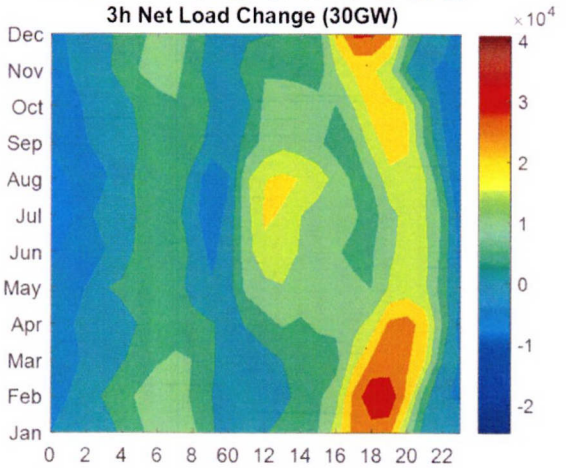
From previous slide….

- In comparison to 2020, on an average
  - there is a marginal increase in the 180-min net load ramps in the 10 GW scenario.
  - the 180-min net load ramps increase by ~50% in the 20 GW scenario.
  - the 180-min net load ramps increase by ~85% in the 30 GW scenario.
  - Winter, Spring and late Summer months have the most prominent changes in extreme 180-min net load ramp magnitudes.
  - In Winter, Spring and late Summer the extreme 180-min net load ramps are correlated with sunset hours.



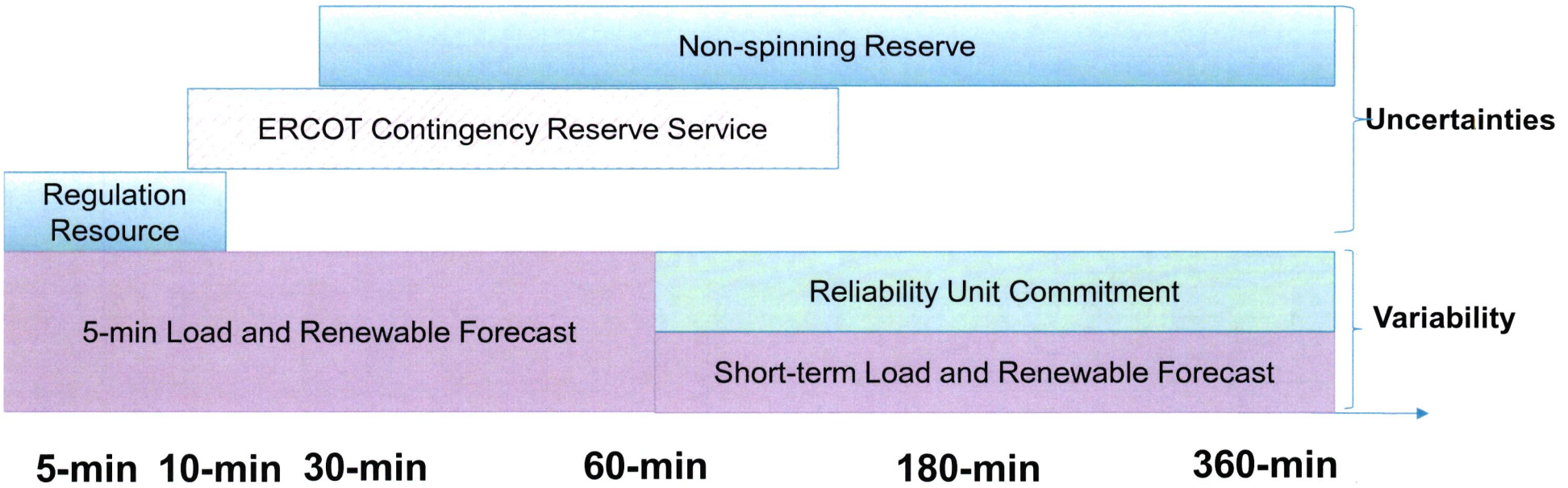






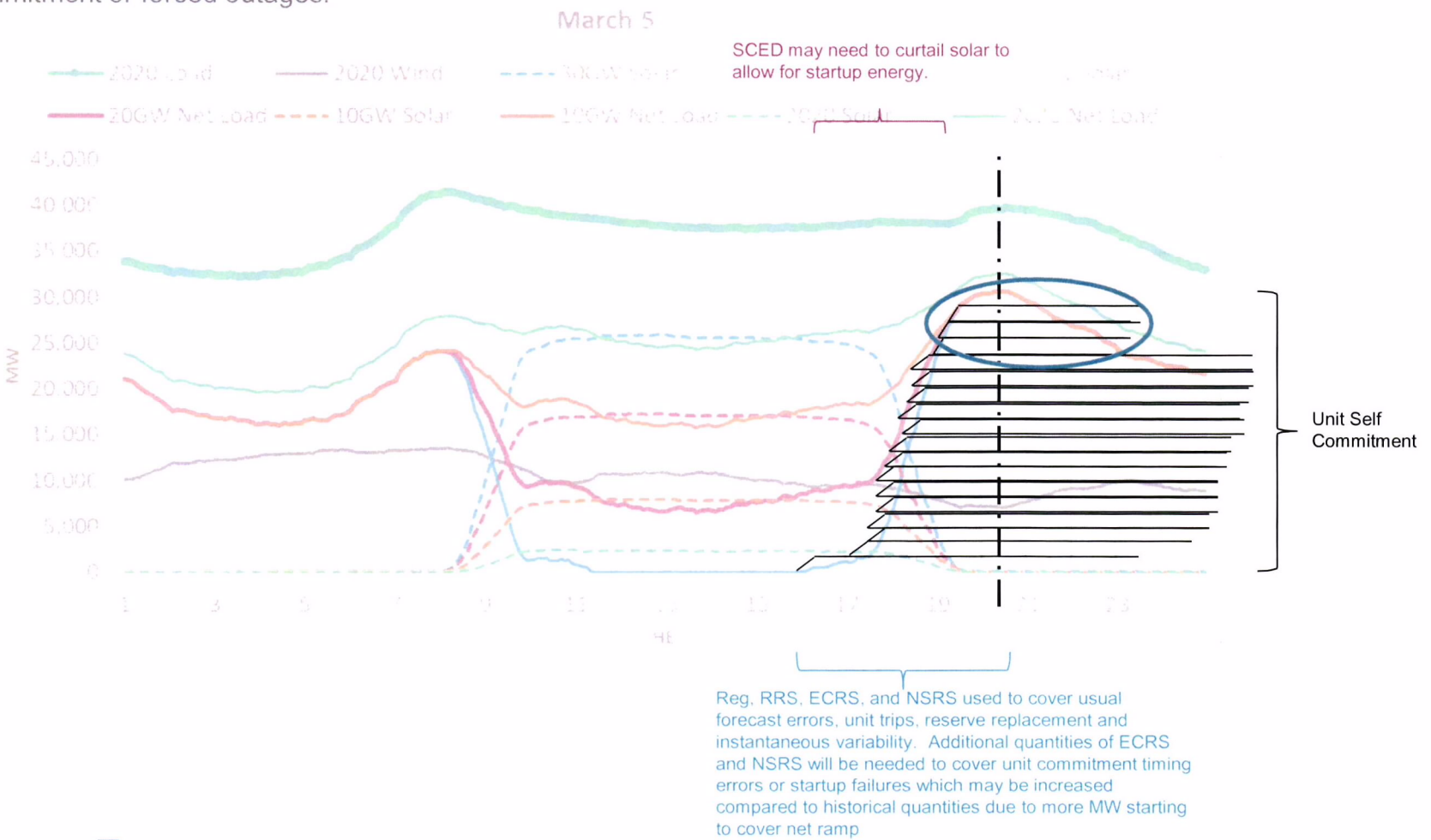
Market and Operations

- ERCOT ensures that there are enough resources and resource flexibility available on the system to meet net load, net load changes, and uncertainties by using Ancillary Services and Reliability Unit Commitment



Net Load Profile - March 5 Some Thoughts

- In focusing on the evening net load up ramp, from grid operations perspective, market's self commitment of resources can be expected to help in responding to bulk of this ramp. However, ERCOT may need to procure incrementally more quantities of Ancillary Services during this period to cover for risks associated with "commitment errors" be it timing of unit commitment or forced outages.



Potential to support this growth in Solar Capacity

- ERCOT may need to consider several changes as the installed capacity for wind and solar increases to these large volumes.
  - Implement ECRS. Solar ramps are typically shorter in duration and ECRS provides a tool that can help respond to short duration system needs.
    - The methodology for computing ECRS quantities to account for net load up ramp related concerns should also be revisited.
  - Continue to improve intra-hour and hourly wind and solar forecast performance.
    - Procure a second solar forecast provider.
    - Add an extreme weather hourly solar forecast model.
  - Implement tools in ERCOT's EMS that will provide ability to monitor forecasted net load ramp and ramping capability of available resources.
  - Reevaluate if the load, wind and solar forecasts inputs used for Reliability Unit Commitment (RUC) assessments should be adjusted such that the highest net load forecast expected within the Operating Hour is studied.
  - Monitor market pricing outcomes to ensure these align with reliability needs.

Summary

- With increase in installed solar capacities, there are substantial changes in net load that can be expected (specially in Winter, Spring and late Summer).
  - Seasonal and temporal variations in net load ramp direction and magnitude can be expected.
  - Larger net load up ramps are likely to be correlated with sunset hours.
    - Based on 2020 load, wind and solar profile i.e. weather data, extremely large net load up ramps tend to occur a small portion time (less than 10%).
  - ERCOT grid and market operations are expected to (and/or should) evolve to support these changes in net load.
    - Timing of implementing some of the changes that have already been approved in the Stakeholder process may need to be revisited.

Max Net Load Up Change (MW)*					
Scenario	5-min	10-min	30-min	60-min	180-min
2020	1094	2154	5944	10595	19191
10 GW	1436	2571	7302	12981	22722
20 GW	3664	5343	9672	17601	31998
30 GW	5466	8022	12259	22417	40684
98th Percentile Net Load Up Change (MW)*					
Scenario	5-min	10-min	30-min	60-min	180-min
2020	729	1265	3290	6442	16763
10 GW	899	1489	3604	6884	17381
20 GW	2245	3197	6106	10233	18285
30 GW	3254	4595	8846	15141	25424
Max Net Load Up Ramp (MW/min)					
Scenario	5-min	10-min	30-min	60-min	180-min
2020	219	215	198	177	107
10 GW	287	257	243	216	126
20 GW	733	534	322	293	178
30 GW	1093	802	409	374	226

*Note: Slide 2 outlines the assumptions that were used in this assessment. This analysis is based on extrapolating the wind and solar generation profiles from 2020. The locations of future solar farms (geographic effect), wind/solar curtailment and dispatch of other resources will change the actual net load ramps the grid experiences.

Discussion